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THE POTENTIAL OF RUBBER AGROFORESTRY FOR RATTAN (*Calamus* sp) CULTIVATION IN KATINGAN REGENCY: DIVERSITY OF CLIMBING TREES FOR RATTAN

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ABSTRACT

A research aimed to evaluate the level of diversity of rattan trees under agroforestry system, was conducted from June to December 2011 in Tumbang (Tb) Kalemei (upstream of Katingan), Tb Hiran (middle) and Tb Liting (downstream) villages, Katingan regency, Central Kalimantan. The data were collected using purposive sampling in rubber agroforestry (RA) and secondary forest (SF). The evaluation of species diversity was measured by species richness, Importance Value Index, and Diversity Index. The results indicated SF had high species diversity, while the diversity level of RA was high in Tb Hiran village. The other two villages had RA in moderate diversity level, and the average of basal area in SF was higher than that of RA. Habitat similarity was characterised by the similar composition and structure of vegetation of both RA and SF in Tb Hiran and Tb Kalemei only. The SF in Tb Liting village was similar to RA, but it differs with SF in Tb Hiran and Tb Kalemei villages. The potential of supporting trees for rattan in RA was quite high based on its high species density and the presence of trees with high to extremely high wood density as found in SF.

Keywords: rattan, rubber agroforestry, diversity of climbing trees, secondary forest

INTRODUCTION

Rattan (*Calamus* sp.) is categorised as vine and grows in clump, which takes advantage of surrounding trees to grow by creeping along the surface of other trees. Rattan growing in secondary forest or disturbed forest can perform maximum growth compared with those growing in primary forests (Rachman dan Jasni, 2008; Pantanella *et al.*, 2005). In Katingan regency, rattan is planted among rubber, cempedak (*Artocarpus chempedan*), durian, (*Durio zibethinus*), lansat (*Lansium domesticum*); and timber trees such as *Shorea sp*, laban (*Vitex pubescent)*, jirak (*Xanthophylum* sp) were also planted around. As the time spins, rattan plantation resembles secondary forest where species diversity is more apparent. The diversity of supporting trees for rattan strongly affects the growth and the number of trunks per clump, and the quality of the trunks (Arifin, 2008).

The secondary forest is used permanently for rattan cultivation, while in rubber agroforestry is only temporarily used (Arifin, 2008). In Malaysia peninsula, the rattan is intercropped with old unproductive rubber plants (Burnet and Morikawa, 2006). In Jambi benefits of intercopping advantage is obtained in the form of latex rubber and resin production, in addition to the implementation of intercropping serve as the starting point in preserving jernang *(Daemonorops sp.*) due to cultivation jernang society is the concept of ecological and economic dimensions (Weinarifin, 2008)

The trees grows along with rattan provides support for rattan to creep up are known as climbing trees. The potential climbing trees are generally strong, have low branches, and grow fast (Martono, 2010). The climbing trees which commonly used for rattan, has other value as medicine, fruit production, building materials and traditional ritual) are Halaban (*V. ubescens*), Bungur (*Lagesrstroemia speciosa*), Bayur (*Pterosperma javanicum*), Rambai (*Sonneratia caseolaris*), Meranti (*Shorea sp*), Sagagulang (*Bumeodendron kurxii*) and Karet (*Hevea brasiliensis*) (Arifin, 2011; Rawing, 2009; Anonymous, 2006). Therefore, the diversity of

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climbing trees in rubber agroforestry is considered high.

Almost all types of tree can serve as a climbing tree for rattan, but information on ecological as well as economic value of each species is not yet known. This research is addressed to evaluate the diversity of climbing trees for rattan in rubber agroforestry system and in secondary forest. Information of diversity of climbing trees in agroforestry systems is very important point for improving management strategy for producing good quality of rattan in Katingan regency.

MATERIALS AND METHODS

This research was conducted from June to December 2011 in three villages: Tb Hiran (upstream), Tb Kalemei (middle) and Tb Liting (downstream), Katingan regency, Central Kalimantan are located between $0^{0}20'$–$3^{0}30'$S and $112^{0}00'$ – $113^{0}45'$ E (Figure 1), which have a large area of rattan agroforestry with varied quality, different bio-physical condition and the altitude. Each site was selected two types of land use systems i.e. rubber agroforestry (RA) and secondary forest (SF). The RA consisted of 30-year-old rubber, and it is a transition from primary forest to traditional agricultural cultivation system. Initially farmer planted rice and vegetables for family consumption before it changed into mix garden planted with rubber, rattan, fruit tree, and timber tree. Similarly, SF was initially primary forest, which then changed into mixed garden in which many species of trees are planted.

Figure 1. Location of the research, Katingan regency

Establishing Observation Plot

Transect was made on 40 x 40m^2 (0.16 ha) plot of the total area of 6 plots (0.96 ha). Furthermore, within each plot was made a transect of 240m x 20m (Figure 2). The size of observation plots varied according to the growth stage of the trees observed by taking nested sampling: tree of 20 x 20 m^2, pole of 10 x 10 m^2 and sapling of 5 x 5 m^2. The total number of sub plots in every village was 36 subplots for all growth stage in both RA and SF, or 108 subplots in total. Plot samples of each transect were illustrated in Figure 2. Vegetation observation was done in every growth stage: tree (DBH>20 cm), pole (young tree DBH 10 – 20 cm) and sapling (height>1.5 m and DBH<10 cm).

Observation of Tree Species Diversity

Diversity of tree species observed includes: (1) species identification; (2) total individu per species; (3) trunk diameter (DBH); (4) plant height; and (5) wood density. The species identification was conducted in the laboratory of Dendrology, Forestry Department, Agriculture Faculty, Palangka Raya University. The measurement of tree diameter (DBH) was done on the trunk at 1.3 m from soil surface. The total tree height and the height free from branches was measured using Suunto hypsometer, while the measurement of poles was done by measuring the diameter of the total height and the height free from branches.

Wood Density (WD)

Wood identification of each tree was obtained by referring to wood density in tropical regions (http://db.worldagroforestry.org/wd). Wood density was categorised into 4 levels: (1) low (<0.6 g cm^{-3}); (2) moderate (0.6 – 0.75 g cm^{-3}); (3) heavy (0.75 – 0.9 g cm^{-3}); (4) very heavy (>0.9 g cm^{-3}) (world agroforestry, 2013).

Basal Area (BA)

Basal area illustrates the area covered by vegetation, calculated as follow:

$$BA = \pi\ (D)^2/4 \quad \text{....................................(1)}$$

Note:
BA = Basal Area (m^2); D = DBH (m)

Biodiversity Measurement

Importance Value Index (IVI) is a quantitative parameter used to measure the dominance level of species in a community. IVI is a total of relative density, relative frequency and basal area/relative domination with the maximum value of 300%. The Importance Value Index is calculated using equation developed by Indriyanto (2006):

Importance Value Index (IVI) = RD + RF + RD ..(2)
Notes:
RD = Relative Density;
RF = Relative Frequency
RD = Relative Dominance

The measurement of Biodiversity Index involves Richness index, diversity index and evenness index.

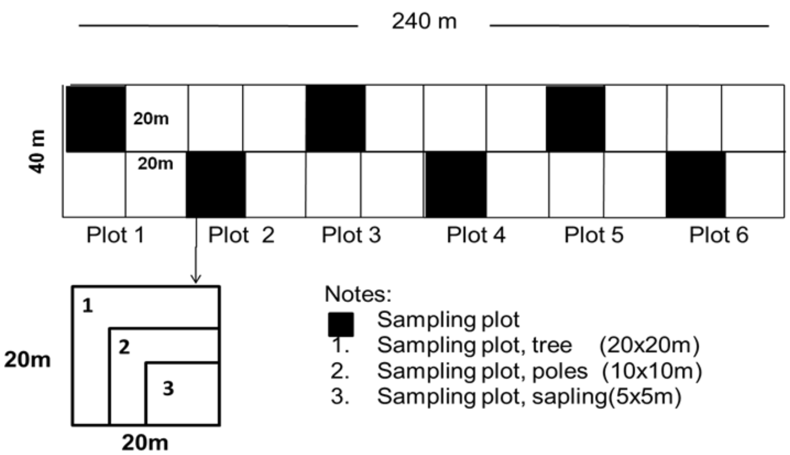

Figure 2. The design plots observed in RA/SF (Indryanto, 2006)

Biodiversity Index

The equation developed by Shannon and Wiener have been used to calculate biodiversity index as follow:

$$H' = -\Sigma\{(ni/n)\ln (ni/n)\} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where:
H' = Diversity Index;
Ni = number of individuals;
N = total number of individuals with the following criteria:
H' 0 – 2 = indicates low species diversity level,
H' 2 – 3 = indicates moderate species diversity level,
H'>3 = indicates high species diversity level

Richness Index

Richness index was calculated by applying Menhinich Index , as follow:

$$R=S/\sqrt{n} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where:
R = richness index;
S = number of species;
n = total number of individuals

Evenness Index

Evenness index was measured to determine whether the species in a particular growth stage were evenly distributed.

$$E = \frac{H'}{Ln\,(S)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where:
E = evenness index;
H'= species diversity index;
S = number of species available

Cluster Analysis

Cluster analysis is known as multivariate technique to cluster objects according to their characteristics. Cluster analysis in this research was togroup the objects statistically (villages and land cover) according to parameter similarity (tree density, domination and number of species, diversity index, wood density and basal area). Parameter clustering was done to find out species similarity between land covers and representative villages by applying similarity analysis based on Bray-curtis Index Values (0-1), when level of similarity is close to 1 is considered as high. Further analysis is done to find out the spatial distribution pattern of species by applying Morisita distribution index (Krebs, 1989), using PAST programme (Paleontological statistic).

RESULTS AND DISCUSSION

Composition and Species Density

From the survey we learned that the local farmers had grown rubber and rattan already for 30 years (since 1982). The results of inventory and identification of species and the number of individuals found in SF and RA showed that there were 56 species with 319 individual plants in the upstream area in Tb Hiran, followed by Tb Kalemei with 43 species and 250 individuals, and in the village of downstream area Tb Liting was found 34 species with 254 individual plants. The number of species and species density per hectare in each type of land cover in three different villages are presented in Table 1.

In both SF and RA of Tb. Hiran were found 36 and 34 species, respectively, where 14 species of that number were similar Species. Fifteen similar species were discovered in both SF and RA of Tb Kalemei, while the lowest number of species was found in Tb. Liting within SF (26 species) and RA (19 species) out of that number was found 11 similar species. The plant density in Tb Hiran was higher than that of Tb Kalemei and Tb Liting. Tree species in both land covers in Tb Hiran spreading evenly in each plot with higher density than in Tb Kalemai and Tb Liting which tend to be more sporadic and lower tree density (Table 2).

Large trees

The tree size in Tb Kalemai is bigger than in the other sites, the presence of big trees (DBH> 20cm) is 23% in SF and 27% in RA, while in Tb Hiran and Tb Liting the density of big trees in SF is similar to in RA, average of 21% in Tb Hiran and about 19% in Tb.Liting (Figure 3). The most common trees found in RA of Tb. Kalemei is rubber (*Havea Brasiliensis)* about 41%, followed by *Macaranga sp*. (20%). Although tree density found in RA is high, but mostly are less productive rubber trees. While in SF, the most common species is also *Macaranga sp* (21%) and *Xantophyllum sp.* (20%).

Wood Density (WD)

The good quality of timber commercially is characterised by high level of wood density, it can be used as indicator of a suitable climbing tree for rattan, providing a stable and strong support for rattan to climb up to get more low. In the three different villages observed, the distribution of wood density (WD) in SF and RA ranged from 0.4 – 1.1 g cm^{-3}, the distribution of wood density observed in each land cover of the three villages is presented in Figure 4. In Tb. Hiran, the highest wood density (>0.9gcm^{-3}) was shown by Belawan (*Tristaniopsis whiteana*)and the lowest density (<0.6 gcm^{-3}) was by Tahantang tree (*Campnosperma auriculatum*).

In all three sites observed, the majority of tree population was dominated by woods categorised as moderate as much as 39% and 49% in SF and RA, respectively. However, it was only 17% of the total tree population categorised as extremely high (wood density > 0.9 g cm^{-3}). On the other hand, the number of species with the wood density categorised as extremely high in RA was 6% and 14%, and the percentage of trees categorised as extremely high was only 7% and 10% in SF and RA, respectively.

Trees categorised as extremely high wood density in SF and RA of Tb. Hiran were dominated by the *Dipterocarpaceae* family such as Bangkirai (*S. laevis*), Keruing (*D elongates*) and Benuas (*H. celebica*), and some other tree species like Buring (*Diospyros sp.*) and Bengaris (*K. malaccensis*). Not like Tb. Kalemei which is geographically located in the transition point of lowland and highland, SF and RA had more tree species categorised in extremely high density of non-*Dipterocarpaceae* family: Buring wood (*Diospyros sp.*), Lasi (*A. fagifolia Ridl*) and Belawan (*T. whiteana*). While in the downstream area Tb. Liting, the tree species having the same wood density were Butun (*H. cratoxylon*), Bengaris (*K. malaccensis*) and Belawan (*T. whiteana*).

Basal Area (BA)

Basal area in the SF mostly dominated by bigger tree (DBH>20 cm) rather than smaller tree (DBH<20 cm), while in RA basal area of bigger tree is equal to that smaller tree (Figure 5), the average of basal area (BA) in SF was higher than that in RA. The highest basal area (BA) in SF was 25 m^{2}ha^{-1} in Tb. Hiran, and the lowest was in RA in Tb Liting 14 m^{2}ha^{-1}. It shows that trees with small diameter were still found in RA of Tb Liting despite the larger number of species and higher level of density of tree population in RA of Tb Liting compared to Tb Kelemei as shown by data in Table 1.

The low basal area in RA was caused by higher number of smaller DBH trees rather than bigger DBH tree, this system was established 3-5 years later than SF. Figure 6 shows that vegetation in SF of three sites are higher than that in RA, the average of wood density is 0,69 g cm^{-3}of SF and 0,66 g cm^{-3} of RA.

Importance Values Index (IVI)

The dominance of the three plant species according to the growth stage in SF and RA in different villages having high IVI is presented in Table 3. The majority of plants in SF were from *Dipterocapaceae* family, followed by *Podocarpaceae* and *Verbenaceae*, while RA was dominated by the plants coming from the family of *Euphorbiaceae, Sterculiaceae,* and *Dipterocapaceae.*

The large number of dominating species indicates that the balance of biodiversity conservation is well maintained as a result of rattan cultivation done by local community. Besides, the existence of vegetation can contribute significantly to the economy in term of providing environmental services for the sake of the health and nutrition of the societies (Sudarmono, 2011).

Table 1. The number and density of species in three representative villages of Katingan Regency

No	Observation Site	00			Density, trunk ha^{-1}		
		SS	RA	Total	SF	RA	Total
1.	Tb.Hiran	36	34	56	2200	1849	4049
2.	Tb.Kalemei	35	23	43	1784	1087	2871
3.	Tb.Liting	26	19	34	1757	1074	2831

Remarks: SF = Secondary Forest; RA = Rubber Agroforestry

Table 2. Five plant species according to the level of density

Location	Plant species			Plant Density ha^{-1}
	Scientific term	Local term	General term	
Tb.Hiran				
• SF	*Shorea javanica*	Damar mata kucing	Resin	125
	Shorea stenoptera	Tengkawang	Tengkawang	104
	Xantophyllum sp	Jirak	Rattan Stick	108
	Vitex pubescens	Halaban	Laban	108
	Pterospermum javanicum	Bayur	Bayur	92
• RA	*Hopea celebica*	Benuas	Benuas	88
	Shorea leprosula	Meranti merah	Red meranti	88
	Hevea brasiliensis	Karet	Rubber	228
	Vitex sp	Sagagulang	Vitex	80
	Koompasia malaccensis	Bengaris	Kempas	80
Tb.Kalemei				
• SF	*Blumeidendron tokbrai*	Gahung	Tokbrai,Gaham	188
	Xantophyllum sp	Jirak	Rattan stick	162
	Antocephalus sp	Tawe	Jabon	116
	Vitex pubescens	Halaban	Laban	113
	Shorea sp	Meranti	Meranti	137
• RA	*Hevea brasiliensis*	Karet	Rubber	162
	Blumeidendron tokbrai	Gahung	Tokbrai,Gaham	71
	Shorea sp	Meranti	Meranti	94
	Vitex pubescens	Halaban	Laban	80
	Pterospermum javanicum	Bayur	Bayur	50
Tb.Liting • SF	*Combretocarpus rotundatus (Miq)*	Tumih	Prepat darat	92
	Dacrydium xanthandrum	Kayu Alau	Melur	92
	Mitrephora sp.	Pisang-pisang	Pisang-pisang	91
	Shorea paucitflora King	Meranti rawa	Meranti	117
	Syzigium inophyllum	Ehang	Kelat	117
• RA	*Hevea brasiliensis*	Karet	Rubber	162
	M. sumatranus Miq	Belanti	Belanti	117
	Artocarpus lanceifolius	Tilap	Keledang	150
	Vitex pubescens	Halaban	Laban	104
	S. paucitflora King	Meranti rawa	Meranti	113

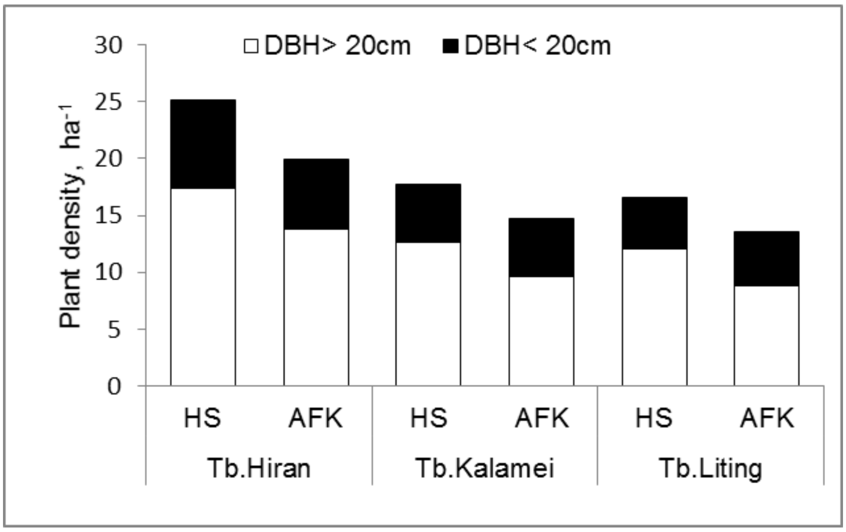

Figure 3. Plant density in SF and RA according to diameter of the trunks

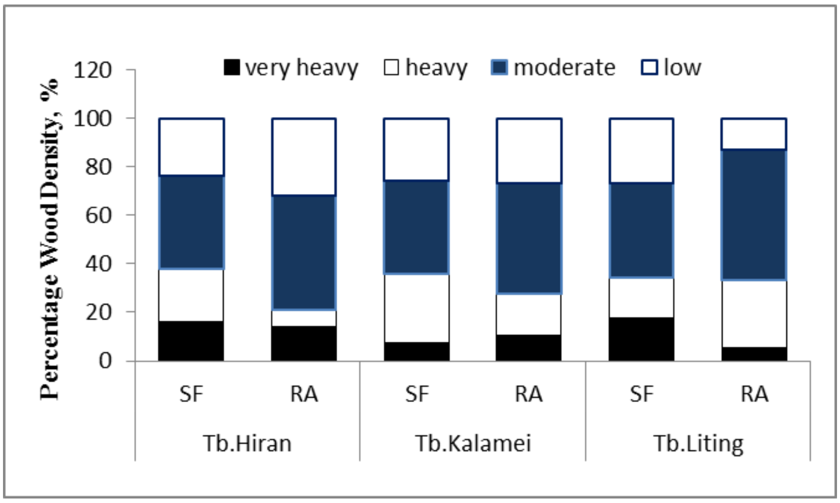

Figure 4. Percentage of distribution of wood density of climbing trees for rattan in secondary forest (SF) and rubber agroforest (RA) in different sites

Species Diversity Index

The observation on SF and RA involved the measurement of species by employing Shannon Weiner diversity index as presented in Table 4. Species diversity is affected by richness and evenness index. The highest diversity level was found in each growth stage in SF and RA in Tb Hiran, as the number of trees found was higher than that of SF and RA in both Tb. Kalemei and Tb Liting. The diversity index in all growth stages of sapling in SF and RA in both Tb kalemei and Tb. Liting was categorized as moderate, for the forest produce was exploited by the locals in order to meet their need for firewood and other purposes. The richness index indirectly obtained followed the diversity index for all growth stages in both SF and RA.

Indriyanto (2006) suggested that species diversity of a community is high when the community consists of varied species. Conversely, a community was considered to have the low diversity when the community consists of only a few species, and there were only a few dominant species. High species diversity level is an indicator that growth environment is stable (Bratawinata, 2006).

Table 3. Tree species according to the highest IVI and their advantages

Site	Growth Stage	Local Term	Scientific Term	Family	Advantage
Tb.Hiran					
• SF	Tree	Keruing	*Dipterocarpus* sp	Dipterocarpa	Buidling material
		Damar Mata Kucing	*Shorea javanica*	Dipterocarpa	Sap, window sill
		Jirak	*Xantopyllum* sp	Podocarpaceae	Plywood, material
	Pole	Keruing	*Dipterocarpus* sp	Dipterocarpa	-
		Halaban	*Vitex pubescens*	Verbenaceae	medicine
		Damar mata kucing	*Shorea javanica*	Dipterocarpa	-
	Sapling	Jirak	*Xantophyllum* sp	Podocarpaceae	-
• RA	Tree	Karet	*Hevea brasiliensis*	Euphorbiaceae	Sap; sawnwood
		Benuas	*Hopea celebica*	Dioterocarpa	Building material
		Jelutung	*Dyera costulata*	Apocynaceae	Sap; Furniture
	Pole	Karet	*Hevea brasiliensis*	Euphorbiaceae	Sap; sawnwood
		Gahung	*B. tokbrai*	Euphorbiaceae	HIV antivirus
		Benuas	*Hopea celebica*	Dipterocarpa	Building material
	Sapling	Karet	*Hevea brasiliensis*	Euphorbiaceae	-
		Bungur	*Lagerstroemia* sp	Lythraceae	Building material
Tb.Kalemei					
• SF	Tree	Sagagulang	*Vitex sp*	Verbenaceae	Building material; firewood
		Jirak	*Xantopyllum* sp	Podocarpaceae	-
		Tawe	*Anthocepalus* sp.	Rubiaceae	Matches; wooden crates
	Pole	Jirak	*Xantopyllum* sp	Podocarpaceae	-
		Gahung	*B. tokbrai*	Euphorbiaceae	HIV anti virus
		Meranti	*Shorea* sp	Dipterocarpa	B. material, moulding
	Sapling	Meranti	*Shorea sp*	Dipterocarpa	-
		Bayur	*Pterospermum* sp	Sterculaceae	carpentry;furniture
		Gahung	*B tokbrai*	Euphorbiaceae	-
• RA	Tree	Karet	*Hevea brasiliensis*	Euphorbiaceae	Building material;
		Meranti	*Shorea* sp	Dipterocarpa	moulding
		Gahung	*B.tokbrai*	Euphorbiaceae	HIV antivirus
	Pole	Karet	*Hevea brasiliensis*	Euphorbiaceae	-
		Halaban	*Vitex pubescens*	Verbenaceae	Medicine; residue
		Meranti	*Shorea* sp	Dipterocarpa	-
	Sapling	Karet	*Hevea brasiliensis*	Euphorbiaceae	-
		Mengkuru	*Knema* sp.	Myristicaceae	Sawnwood
		Jambu	*Memecylon* sp.	Melastomataceae	medicine ; firewood
Tb.Liting • SF	Tree	Kayu Alau	*Dacrydium sp*	Cupressaceae	Construction;furniture
		Tumih	*Combretocarpus* sp	Anisophylleaceae	Sleepers;furniture
		Gahung	*B.tokbrai*	Euphorbiaceae	HIV antivirus
	Pole	Meranti Rawa	*Shorea paucitflora*	Dipterocarpa	Plywood,material
		Ehang	*Syzigium* sp	Myrtaceae	dye
		Nyatoh	*Palaquium* sp	Sapotaceae	B. material; furniture
	Sapling	Kayu Alau	*Dacrydium* sp	Cupressaceae	Construction;furniture
		Ehang	*Syzigium* sp	Myrtaceae	dye
		Gahung	*B.tokbrai*	Euphorbiaceae	-
• RA	Tree	Karet	*Hevea brasiliensis*	Euphorbiaceae	Sap;sawnwood
		Kaja	*Dillenia excelsa*	Dilleniaceae	medicine ; spice
		Halaban	*Vitex pubescens*	Verbenaceae	medicine ; residue
	Pole	Karet	*Hevea brasiliensis*	Euphorbiaceae	-
		Meranti Rawa	*Shorea paucitflora*	Dipterocarpa	-
		Belanti	*M.sumatranus*	Euphorbiaceae	fruit (food)
	Sapling	Karet	*Hevea brasiliensis*	Euphorbiaceae	-
		Belanti	*M.sumatranus*	Euphorbiaceae	Construction;matches
		Bayur	*Pterospermum sp*	Sterculaceae	

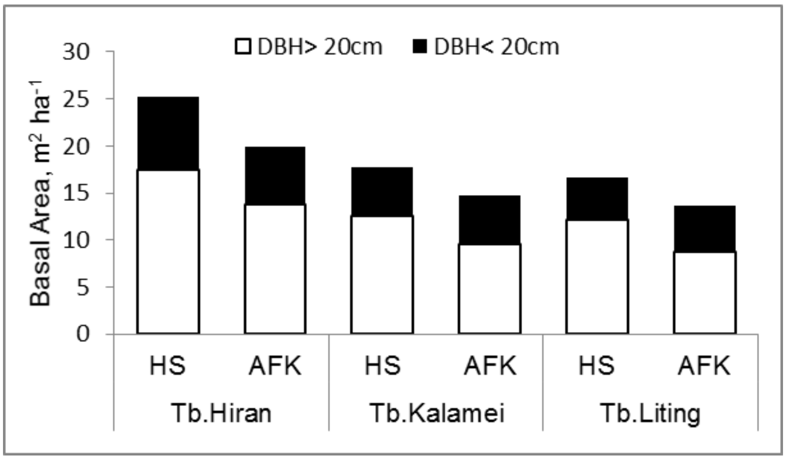

Figure 5. Tree basal area (BA) distribution in secondary forest and rubber agroforestry

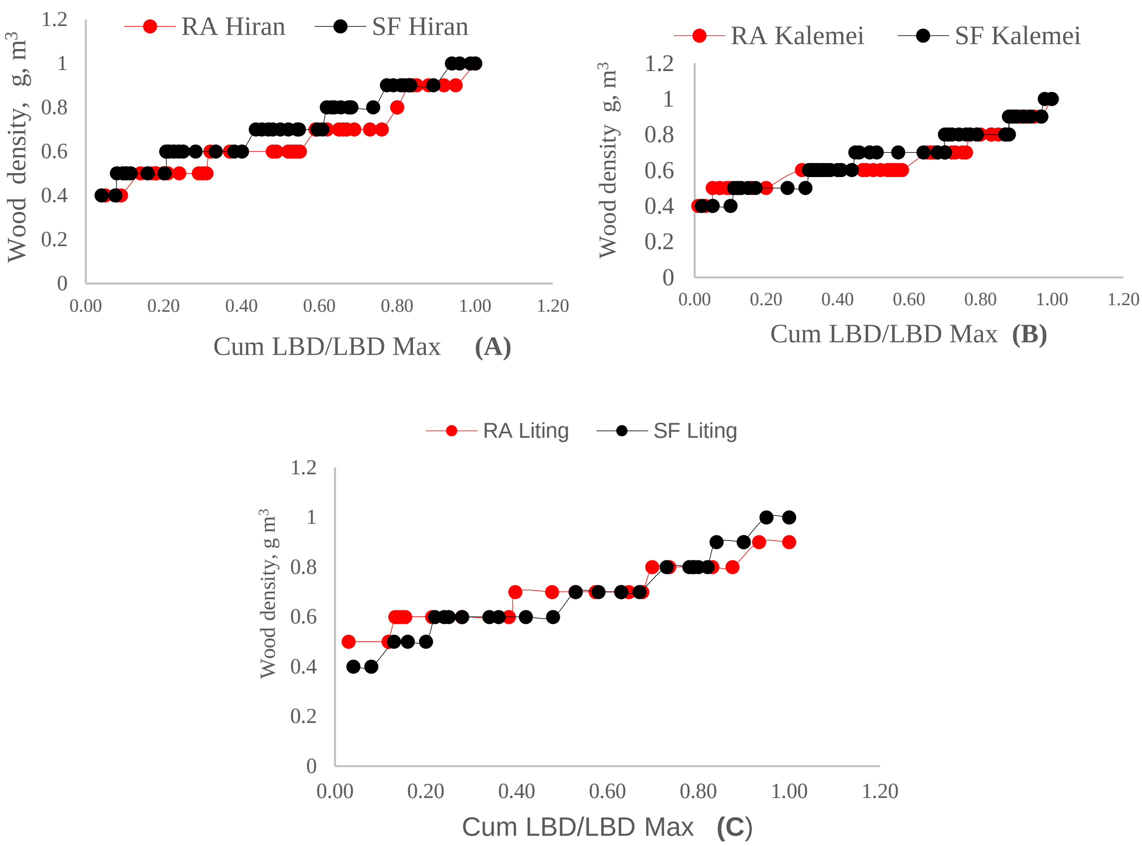

Figure 6. Correlation between density and cumulative basal area (BA) max: (A) Tb. Hiran; (B) Tb. Kalemei; (C) Tb Liting

Tree Species Clustering (Cluster Analysis)

According to analysis on species similarity using Bray-Curtis index value, the results show that there were three clusters based on the types of land cover and villages. Based on Morisita index value (Figure 7), we learned that SF in Tb.Hiran and Tb.Kalemei was in one cluster (0.36); while RA in Tb.Hiran was in one cluster with that of Tb.Kalemei (0.59); and the land cover of SA was in one cluster with RA (0.53) in Tb.Liting. The index value Morisita in Figure 6 is close to 1 meaning that there was similarity and it could be clustered. The habitat characterized by its composition and vegetative structure in Tb.Hiran and Tb.Kalemei showed similarity in both SF and RA, unlike that in Tb Liting, where SF was not far different from RA, but it was strongly different from SF in Tb.Hiran and Tb.Kalemei village.

Similarity parameter shows that SF in Tb. Kalemei was characterized by some common species which had density, number of individuals, dominance, and a number of higher valued species such as *C. auriculatum*, *Anthocepalus sp*., *P. javanicum*, *B. kurxii*, *Mangifera sp*., *Xanthophylum*, *Shorea sp* and *Dysoxylum*. While the high values in wood density, basal area, diversity (H’) and Richness (R) were characterized by *C. auriculatum*, *Anthocepalus sp*., *P. javanicum*, *B. Kurxii*, *Mangifera sp*., *Xanthophylum* and *Shorea sp*., for SF in Tb.Kalemei (Figure 8A). The RA system in Tb. Kalemei had structure and vegetative composition with the dominance shown by *Aporusa sp*. Large number of species was characterized by *Xanthophylum sp*., *A. campeden*, *Shorea sp*., *P. javanicum* and *Mangifera sp*., while the high values in density and the number of individuals were indicated by *H. brasiliensis*, *Litsea sp*., *Sterculia* and *Q. subsericea* (Figure 8B).

Aporusa sp also characteristic species in RA in Tb. Kalemei with shown by a quite high basal area, while high diversity was indicated by *Xanthophylum*. High values in density and richness were indicated by *Mangifera sp*., *P. javanicum*, *Shorea sp*., and *Sterculia sp*. The SF of Tb. Hiran had plenty of characterising species with high values in the number of individuals, density, dominance, and the number of species such as *S. javanica*, *Xanthophylum sp*., *V. pubescens*, *D. elongates*, *p. javanicum*, *B. kurxii*, *S. stenoptera*, *Sterculia*, *C. auriculatum*, *Diospyros sp*., *S. laevis*, *Macaranga sp*., *Phoebe sp*., *A. cadamba* and *Q. subsericea*. Species such as *Xanthophylum sp*., *S. javanica*, *S. stenoptera*, *Sterculia sp*., *C auriculatum*, *A. cadamba* and *P. javanicum* contributed high values in parameters such as basal area, richness, and diversity in secondary forest of Hiran village (Figure 8C). Rubber agroforestry in Tb Hiran village had relatively similar number of species, density, dominance and individuals, and three of the species such as *Ptenandra sp*., *A. jiringa* and *Myristica sp*. had the most insignificant values among the others. Meanwhile, species like *H. brasiliensis*, *D. lowii*, *S. leprosula* and *A. cadamba* had high values in basal area, richness and diversity. *Palaquium amboinensis* and *H. sangal* had moderate values in basal area, richness and diversity (Figure 8D).

Secondary forest of Tb Liting showed that the values of the number of species, density, dominance, and the number of individuals were generally similar. The highest basal area, richness and diversity were found in *C. auriculatum, C. arborencens* and *G. bancanus*. *Sterculia sp., Phoebe sp., D. lowii, Vitex sp., S. paucitflora, M. sumatranus*. Rubber agroforestry in Tb Liting village had insignificant values in the number of species, density, dominance and the number of individuals, found in *G. bancanus* and *T. whiteana*, but other species showed the opposite. Moreover, *P. javanicum, S. paucitflora* and *A. lanceifolius* reperesented high basal area, richness and diversity in RA of Liting village (Figure 8F).

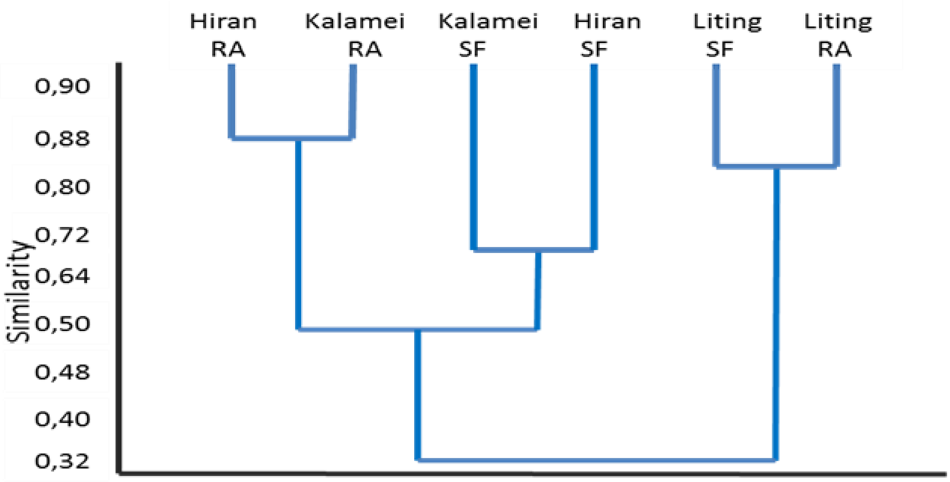

Figure 7. Morisita index cluster on Secondary Forest (SF) and Rubber Agroforestry (RA) in three selected villages

Table 4. Analysis result on species diversity according to growth stage

Site	Growth Stage	Diversity Index (H')	Richness Index (R)	Evenness Index (E)
Tb.Hiran				
• SF	Tree	3,40	6,77	1,15
	Pole	3,53	7,31	0,97
	Sapling	3,51	7,74	1,01
• RA	Tree	3,96	7,12	1,11
	Pole	3,39	7,59	0,95
	Sapling	3,41	7,63	0,96
Tb.Kalemei				
• SF	Tree	3,61	7,06	1,01
	Pole	3,58	6,60	1,04
	Sapling	2,69	4,22	0,95
• RA	Tree	3.72	5,07	1,17
	Pole	3,37	3,33	1,24
	Sapling	2,11	3,00	0,87
Tb.Liting				
• SF	Tree	2,87	5,67	0,96
	Pole	2,71	5,40	0,99
	Sapling	2,76	5,45	0,96
• RA	Tree	2,42	4,50	1,10
	Pole	2,29	4,39	1,01
	Sapling	2,30	4,40	0,96

Remarks: Index value criteria (Magurran,1988 ; Krebs, 1978 ; Kusmana, 1995)

H' = 0 – 2 (Low)	R = < 3.5 (Low)	E = < 0.3 (Low)
H' = 2 – 3 (Moderate)	R = 3.5 – 5 (Moderate)	E = 0.3 – 0.6 (moderate)
H' = >3 (High)	R = > 5 (High)	E = > 0.6 (High)

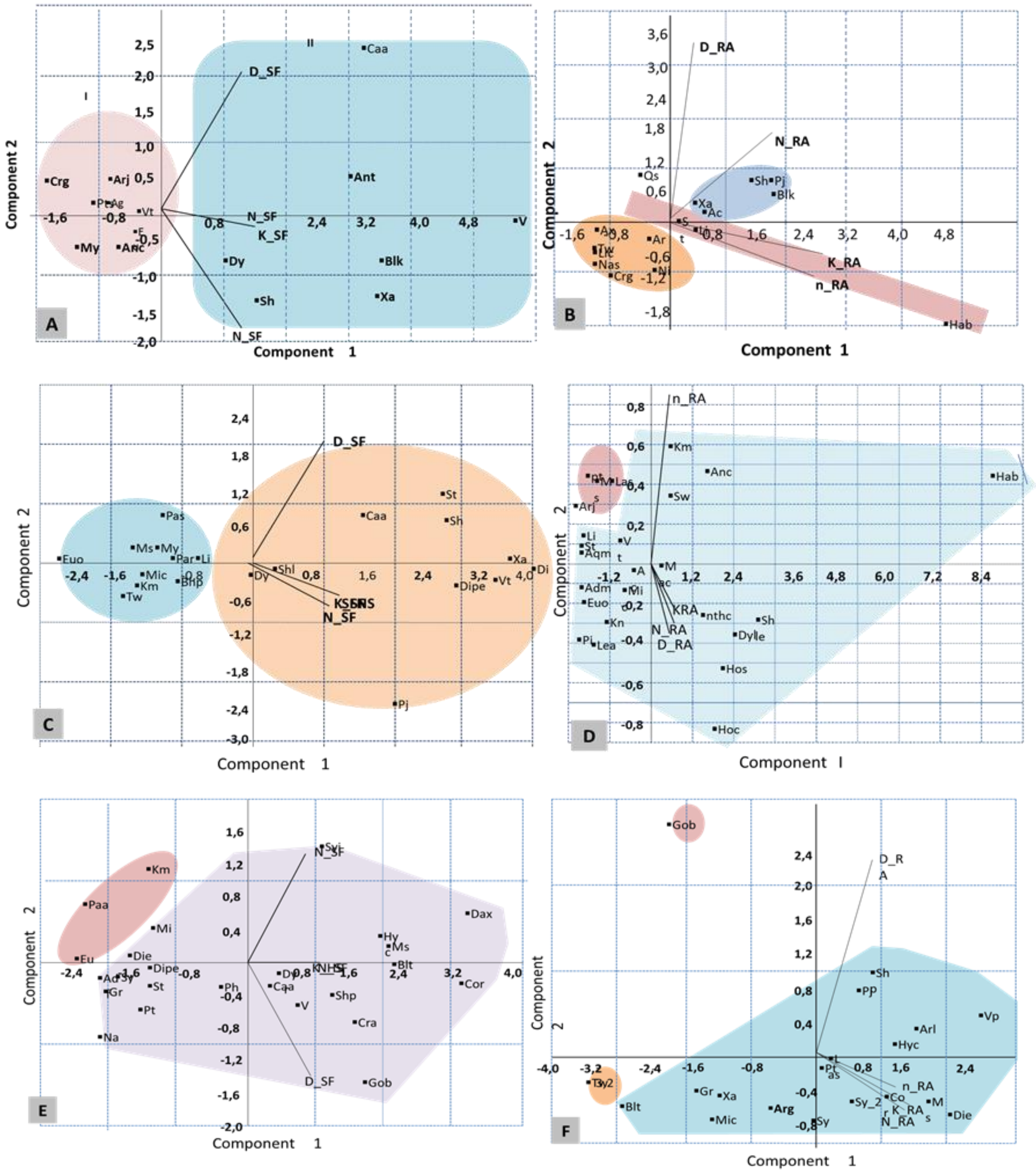

Figure 8. Tree species clustering in SF (A) and RA (B) in Tb. Kalemei; SF (C) and RA (D) Tb. Hiran; SF (E) and RA (F) in Tb. Liting according to the number of species (N), density (Dn), dominance (D) and the number of individuals (n).

CONCLUSIONS

Secondary forest (SF) represented the largest number of species in upstream village Tb. Hiran (36 species), followed by Tb. Kalemei (35 species) and lowest is in downstream village Tb. Liting (26 species). The highest diversity index was reflected in the growth stage of tree (3.2 – 3.6), pole (3.2 - 3.6), and sapling ranging from moderate to high (2.7-3.5).

Rubber Agroforest (RA) shows the largest number of species in Tb. Hiran with 34 species, followed by Tb. Kalemei, and Tb. Liting with 23 and 19 species, respectively. The highest species diversity index reflected in the growth stage of tree (3.2-3.9), pole (3.0-3.4), and sapling ranging from moderate to high (2.1-3.4). The percentage indicates that SF and RA have the largest number of tree species with wood density ranging from 0.6-0.75 gcm^{-3}, although a few number of trees with wood density bigger than 0.9 gcm^{-3} were also found.

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